

DOCUMENT RESUME

ED 374 407

CS 011 836

AUTHOR Thompson, David R.
TITLE New Technology and the Newspaper of the Future: Some Effects of Modality, Story Type, and Search Experience on Information Location.
PUB DATE Jul 94
NOTE 36p.; Paper presented at the Annual Meeting of the International Communication Association (44th, Sydney, New South Wales, Australia, July 11-15, 1994).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Higher Education; *Information Retrieval; *Information Seeking; *Man Machine Systems; *Newspapers; Reading Research; *Technological Advancement; Text Structure; Undergraduate Students
IDENTIFIERS Journalism Research; Multimedia Technology; *News Stories; Technology Utilization

ABSTRACT

Anticipating a possible future method of multimedia newspaper design and delivery, a study examined the interface among people, modality (paper, computer, multimedia), and three types of news story (news, sports, entertainment). Subjects, 55 undergraduate students enrolled in journalism classes and 20 university library employees considered as "expert" searchers, were asked to search for specific information from three different stacks of stories, each stack containing four stories. The search path was recorded and evaluated to determine the number of search errors. A significant effect was found for search time as a function of modality. The multimedia condition had the longest search times, followed by computer and paper. Yet, only 13% of the subjects chose to view the digitized video as a search strategy. Story type was a significant factor. The sports story had the shortest search time, followed by news and entertainment. The sports story had the fewest search errors, followed by news and entertainment. Findings suggest that locating information in an electronic environment seems to take longer than finding information on paper, and that users need to be convinced that searching digitized audio and video may be a productive strategy. (Contains 81 references, 3 tables, 11 figures of data, and 4 notes.) (RS)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

**NEW TECHNOLOGY AND THE NEWSPAPER
OF THE FUTURE: SOME EFFECTS OF MODALITY,
STORY TYPE, AND SEARCH EXPERIENCE
ON INFORMATION LOCATION**

by

David R. Thompson, Ph.D.

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☒ This document has been reproduced as
received from the person or organization
originating it.

☐ Minor changes have been made to
improve reproduction quality.

• Points of view or opinions stated in this
document do not necessarily represent
official OERI position or policy.

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY

D. Thompson

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

Paper presented at the International Communication Association
44th annual conference, Communication and Technology Division,
July 11-15, 1994, Sydney, Australia

David R. Thompson, Ph.D.
Mass Communication Department
Southwest Texas State University
San Marcos, Texas 78666
(512) 245-2656
(512) 245-3708 fax

New address as of August 1994:

College of Journalism & Mass Communications
University of South Carolina
Columbia, SC (USA) 29208
(803) 777-4102
(803) 777-4103 fax

NOTE: This paper is adapted from the author's dissertation. Special thanks to Michael Farris, director, Media Services, Southwest Texas State University. Special thanks to Wayne Danielson, James Tankard, Maxwell McCombs, Diane Schallert, and Philip Gough, of the University of Texas at Austin.

NEW TECHNOLOGY AND THE NEWSPAPER OF
THE FUTURE: SOME EFFECTS OF MODALITY,
STORY TYPE, AND SEARCH EXPERIENCE
ON INFORMATION LOCATION

ABSTRACT

This study anticipates a possible future method of newspaper design and delivery. Some newspapers may include multimedia content -- computer-based information that includes audio and video presented by interactive technology systems. When turning pages becomes navigating in cyberspace, researchers must ask: How do we locate information?

Using an experimental approach, this study examined the interface between people, modality (paper, computer, multimedia), and three types of news story (news, sports, entertainment).

This experiment applied Guthrie's (1988) theory of information location which states that searching for specific information -- a form of problem solving -- is "cognitively distinct" from the reading process. Guthrie and colleagues have studied paper and computer modalities. This experiment added multimedia as a factor.

A significant effect was found for search time as a function of modality. The multimedia condition had the longest search times, followed by computer and paper. Yet, only 13 percent of the subjects chose to view the digitized video as a search strategy.

Story type was a significant factor. The sports story had the shortest search time, followed by news and entertainment. The sports story had the fewest search errors, followed by news and entertainment.

This study provides evidence of some effects of using interactive technology. Finding information in an electronic environment seems to take longer than finding information on paper. Story type should be included in future research. And results of this study suggest training users that searching digitized audio and video may be a productive strategy. Further research of the cognitive effects of using multimedia news presentations is encouraged.

INTRODUCTION

This study anticipates a possible future method of newspaper design and delivery. New computer and telephone technologies have made it possible to conceive of newspapers as computer-based information delivery systems that include audio and video presented by interactive technology systems. When turning pages becomes navigating in cyberspace, researchers must ask: How do we find information?

The ink-on-paper newspaper may never be replaced (Fidler 1991b, p. 121), but news is already being presented using interactive technology.

Kerr (1986, p. 388) discussed aspects of this transition from printed messages to electronic information. He stated:

The challenge is not simply to recreate in electronic text what has been done in print, but to capitalize on what electronic text can do best -- provide rapid access to lots of information, and help to organize and structure the way in which the user interacts with the text. Doing this will require us to not only reconceptualize how the text itself is structured, but also to think more deeply about how it is to be understood and used by the reader.

This experiment examined the interface between people, mass communication messages, and medium of presentation. An experimental approach was used to search for evidence of a possible cause-and-effect relationship between presentation format and cognitive performance of the information location process.

This study seeks evidence of differences in search time and search accuracy across three different modes of presentation. The three modalities are ink-on-paper, computer screen, and multimedia (a computer presentation that includes video and audio).

Multimedia is a system that "supports data other than text" (Nelson 1991, p. 3). Multimedia is sometimes called "hypermedia." The two terms are used interchangeably in this experiment.

Multimedia technology is here and in use. But, as researchers, we must ask: Is it better?

LITERATURE REVIEW & HYPOTHESES

This experiment applied Guthrie and colleagues' theory of information location to mass communication messages (Kirsch & Guthrie, 1984; Guthrie & Kirsch, 1987, Guthrie & Mosenthal, 1987; Guthrie, 1988; Kirsch & Mosenthal, 1990; Guthrie, Britten & Barker, 1991). This theory states that searching for specific information within a document is "cognitively distinct" from the reading process. According to the theory, the information location process is a form of problem solving. Guthrie and colleagues have examined search tasks using paper and computer modalities.

This experiment extended the theory of information location to consider multimedia. Will subjects consider watching the "movie" a productive search strategy?

This study compared performance of an information location task across presentation formats. The unit of analysis was the news story.

The independent variables were search experience (novice, moderate, expert) and modality (paper, computer, multimedia). Another variable included in the experimental design was story type (news, sports, entertainment). Story type was included as a control factor -- to control for prior knowledge of content domains.

The dependent variables were search time and search accuracy. Subjects were asked to perform a search task. For example, the subject was provided with a stack of four sports stories and asked to find the name of the Rangers' coach. The subject must first locate the correct story, in this case a story about a New York Rangers hockey game. Then, the subject searched the story for the correct response, in this case Ron Smith.

Previous research may be applied to predictions and expectations regarding the search experience variable. Some of this research examined computer experience, a subset of search experience. And some of this research was conducted in the field of cognitive science.

Although Fenichel (1980-'81) and Wang, Liebscher, & Marchionini (1988) reported no search experience effect for online searches, other studies reported overall better performance by experts (Chase & Simon, 1973; Chi, Feltovick & Glaser, 1981; Chi, Glaser & Rees, 1982;

Joseph, Steinberg, & Jones, 1989; Kahney, 1983; Larkin, 1980, 1983; Leung, 1989; Norman, 1982; Norman & Schwartz, 1987; Rumelhart & Norman, 1981; Simon & Simon, 1978).

To date, the author's literature review has failed to disclose studies on multimedia involving search tasks.

To test for a main effect for search experience, This experiment predicted:

H1 A significant main effect will exist for search experience on search time. Expert searchers should have the shortest search times, followed by moderates and novices in that order.

H2 A significant main effect will exist for search experience on search errors. Expert searchers should have the fewest search errors, followed by moderates and novices in that order.

Previous studies have found superior search time performance for print as compared to computer searches (Bates, 1981; Creed, Dennis, & Newstead, 1987; Dreher & Guthrie, 1990; Elchesen, 1978; McGoldrick, Martin, & Bergering, 1989; Wang, Liebscher, & Marchionini, 1988; Haas & Hayes, 1985a, 1985b).

To date, no studies on multimedia involving search tasks have been discovered by the researcher's literature review.

To test for a main effect for modality on search time, this experiment predicted:

H3 A significant main effect will exist for modality on search time. The paper modality should yield the shortest search times, followed by computer and multimedia in that order.

The act of selecting and viewing the QuickTime¹ movie may result in increasing search times for the multimedia condition. The question was:

R1 Do subjects choose to search the video?

Previous research has found a difference in performance of accuracy tasks between print and computer modalities. According to this research, accuracy is better for print (Osborne &

¹ For this study, digitized audio and video is enabled by QuickTime by MacIntosh. QuickTime is an extension to Apple's System 7.0 or System 6.0.7.

QuickTime movies run at about 15 frames per second whereas full-motion video runs at 30 fps (Don 1992).

Holton, 1988; Wright & Lickorish, 1983; Wilkinson & Robinshaw, 1987; Creed, Dennis, & Newstead, 1987; Dreher & Guthrie, 1990; McGoldrick, Martin, & Bergering, 1989).

No studies on multimedia search tasks have been found by the author, to date.

To test for main effects for modality on search errors, This experiment predicted:

H4 A significant main effect will exist for modality on search errors. The paper modality should yield the lowest number of search errors. The number of search errors in the computer and multimedia modalities may be nearly equal.

No directional hypotheses have been constructed for story type. However, significance tests will determine whether or not a main effect exists for story type in this experiment. Also, statistical analysis will determine patterns in performance among levels of the story type variable for search time and search errors. This study asked:

R2 Does a significant main effect exist for story type on search time? What story type results in the shortest search times? longest search times?

R3 Does a significant main effect exist for story type on search errors? What story type yields the fewest search errors? the most?

No directional hypotheses have been constructed for order. However, significance tests will determine if a main effect exists for experimental order. Also, statistical analysis will determine patterns in performance among the three orders (combinations of modality and story type) for search time and search errors. This study asked:

R4 Does a significant main effect exist for order on search time? What order (combination of modalities with story types) yields the shortest search times? the longest?

R5 Does a significant main effect exist for order on search errors? What order is associated with the fewest search errors? the most?

METHOD

Experimental Design

A randomized 3 X 3 Latin Square design was used. The cells of the Latin Square were constructed by combining modality (paper, computer, multimedia) and story type (news, sports, lifestyle). The rows of the Latin Square were treated as experimental orders.

Figure 1. The Latin Square design

Order 1	C + N	P + S	M + E
Order 2	P + E	M + N	C + S
Order 3	M + S	C + E	P + N

Modality

P = Paper

C = Computer

M = Multimedia

Story Type

N = News

S = Sports

E = Entertainment

This design provides a foundation for discovery of main effects. However, because the experimental design is not fully factorial, the Latin Square includes a "designed confound" that makes it impossible to reliably detect interactions between variables.

Analysis of the data will reveal main effects for each independent variable (for example: Does a significant main effect exist for modality?). Analysis of variance will be used for this analysis.

Then, analysis will examine effects between levels of an independent variable (for example: Does a significant difference exist between the paper and computer modalities for reading time?). Contrasts, or focused F-tests are performed for this analysis.

This Latin Square was treated as a within-subjects design. Each subject saw each modality and each story type. The orders determined the combination of story type and modality to which each subject was exposed, and subjects were randomly assigned to orders.

The experimental task was: "Find [this] specific information." To test for differences in search performance across levels of search experience, modalities, and story types, twelve stories were used as stimulus materials. The search involved three information location tasks in "stacks" of each type of story -- one task per story type. Each stack contained four stories.

This means, for example, that Subject #1 was asked to find: 1) specific information about a news story from a stack of four news stories presented in the computer modality; 2) specific information about a sports story from a stack of four sports stories presented in the paper modality; and 3) specific information about an entertainment story from a stack of four entertainment stories presented in the multimedia modality.

The independent variables were search experience, modality, and story type. Also, data analysis treated order as a factor.

Following Guthrie, Britten, & Barker (1991, p. 308), performance measures for this experiment were search time and accuracy.

Search time was operationalized as the total time required to locate the correct answer to each question.

Accuracy was operationalized as the number of search errors made while attempting to answer the question. This included an incorrect answer, an incorrect story choice, and errors using the search functions.

Story order in each stack was randomized in each of the three experimental orders.

In the computer and multimedia modalities, the subject navigated by using four search functions (category, previous, next, find).

Search experience was determined by results of a pre-test questionnaire.

Subjects

Seventy-five individuals participated in this study. Fifty-five of those were U.S. undergraduate students enrolled in journalism classes who participated for course credit. Twenty subjects were university library employees, recruited as "expert" searchers. These subjects volunteered their time. All subjects were debriefed about the purposes of the study afterwards.

Materials

A selective sample of stories was used in order to accommodate the multimedia condition. The multimedia condition required a short (5-8 second) "sound bite." This method was used to avoid the expense of producing news stories.

Twelve stories were selected -- four for each story type (news, sports, lifestyle).

The source of the stories was CNN "Headline News," January 10-14, 1993 (Sunday - Thursday). For this experiment, twelve stories from a sample of 48 were selected -- four for each story type (news, sports, entertainment). Stories considered for selection included enough information to write a 180-word print story and had a 5-8 second audio-video segment that could stand alone as a sound bite.

Following Osborne & Holton's (1988, pp. 4-5) suggestions for experimental controls, stimulus materials used in this paper were written by the researcher. See [Figure 2](#) for an example of a story layout used in this experiment. Each story unit included a headline, text, photo, and photo caption. This story format was based on a review of mass communication literature (Bain, 1980, p.2; Pasternack & Utt, 1986, p.33; Pippis, 1985, p. 1; Van Nes, 1986, pp. 116-117; Barnhurst, 1991, pp.21-22; Tinker, 1966, p. 169; Matazzoni, 1992, pp. 18-19; Kolers, Duchnick, & Ferguson, 1981, p. 525; Dillon, Richardson, & McKnight, 1990, p. 224).

All stories were the same length, about 180 words. All stories were tested for equivalence in readability. Story format and size was held constant across all stories and modalities -- except when multimedia brought the images to life with video and audio

One story per page or computer screen was used. Page turns and "jumps" to another page were considered confounding variables and were avoided in this research. A landscape (horizontal, 11 x 8-1/2) format was used. The story was set in three columns -- two even columns of text with the image and caption in the third, right-hand column.

Headline type was set flush left/ragged right in 30-point Helvetica bold. Body type was set flush left/ragged right in 12-point Palatino. Caption type was set flush left/ragged right in 10-point Palatino. Upper- and lower-case letters were used. And, the layout used included ample white space, so the page and screen were not filled with text.

Pictures (four-color process) and graphics windows were placed in the same location on the page and were the same size. This minimized confounding between experimental conditions.

Dolly Wins CMA Award

Dolly Parton was the guest of honor Wednesday at the Country Music Association's award ceremony. Parton received the Country Music Honors Award. This is the first time such an award has been given.

The singer and sometime actress was cited for her outstanding achievements and upstanding character.

"This is a dream come true. I don't believe it. I'll take it, but I don't believe it," Parton said as she accepted the award.

"No one deserves it more," Loretta Lynn said.

Garth Brooks, Tammy Wynette, Randy Travis and K.T. Oslin were on hand to congratulate Parton.

Parton said, "This deserves a celebration. The rides are free tomorrow at Dollyland." Dollyland is Parton's theme park near her hometown of Daleville, Tennessee.

The event was held at the Grand Ole Opry in Nashville. CBS broadcast the event.

One viewer in Parton's hometown, Daleville, said, "It's about time. Dolly has done a world of good for herself and her fans. We just love her to death around here."



Dolly Parton appears in the movie "Straight Talk."

Figure 2. An example of the stories used as stimulus materials

To construct the multimedia condition, the CNN video clip was digitized for storage as a computer file. The video was captured on VHS tape. The video output of the videocassette recorder was plugged into a video spigot card on a Macintosh computer. The VHS audio output was plugged into the built-in audio input on a Macintosh Quadra 950.

The application Screen Play was used to record the video clip and save it on the computer. Then, the QuickTime Movie Player application was used to edit the digitized videos. The edited videos were then saved as self-contained QuickTime movies.

The digitized video files were not compressed. This avoided degradation of the quality of the images.

Each video was then stored in a separate file on a reloadable hard disk. A HyperCard command loaded the proper image or video into each story as needed.

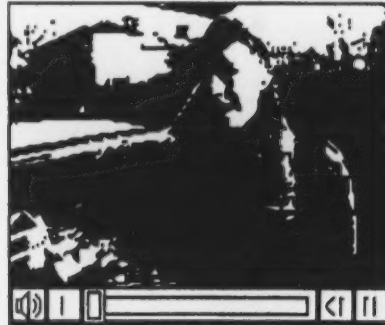
HyperCard allowed the use of hypertext linkages. Hypertext is "a computer-based system that allows immediate, nonsequential access to linked items of information" (Marmion 1990, p. 7).

This study does not test hypertext. However, the linkage between information nodes² applied in hypertext provides a foundation for multimedia applications.

A story template in HyperCard determined the size and placement of the image. The video clip appeared as a still frame. This was actually the first frame of the QuickTime movie. A "play" icon (a thin vertical bar near the bottom left-hand corner) appeared in the QuickTime control strip at the bottom of the image. A click of the mouse on this button activated the video. The subject controlled this interactive interface.

² Slatin (1990, p. 877) defines link and node. "Linkage, in hypertext, plays a role corresponding to that of sequence in conventional text. ... A node is any object which is linked to another object."

Figure 3. Movie control bar used to activate the QuickTime movie in the multimedia condition



This was the multimedia condition.

The computer condition was the same -- except there was no video control strip. The same still image that was the first frame of the video served as a photograph in the computer condition.

The paper condition was the same as the computer condition -- except it was a high-quality color laser print.

This experiment included search functions so the subject could navigate through the computerized material.

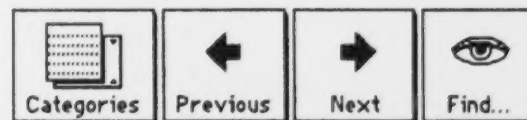
This study applied existing research to construct search functions for the computer and multimedia modalities (Nielsen 1990a, p. 298; Pullinger, 1984, p. 177). Search functions designed for this experiment included: 1) "Category" -- A list of the titles of the four stories in the order that they appeared in the stack. The subject could select the title by clicking the mouse, click on "Okay" and jump ("go to") directly to that story. 2) "Previous" -- By clicking on this function, the subject could move backward in the stack one story at a time. 3) "Next" -- By clicking on this function, the subject could move forward in the stack one story at a time. 4) "Find" -- By clicking on this function, the subject could type in a keyword for which the computer would search. If the word was found, the story with that word would appear and the word would be highlighted.

Also, subjects were not required to memorize the search functions -- all search function icons remained on the screen at all times. Search icons are graphic representations of the function performed by selecting, or using that icon.

Existing research was consulted for recommendations of icon use on computer function "buttons" (Gittins 1986, p. 519; Guastello & Traut, 1989, p. 99; Muter & Mayson, 1986, p. 89).

Figure 4 demonstrates the mixed modality icons used in this experiment.

Figure 4. Search function icons used for this experiment



When the subject used the mouse to "click" on the categories icon, a list of the titles of the four stories appeared. From here, the subject could go directly to a particular story by selecting it with the mouse. The "Previous" and "Next" icons were used to move backward or forward one story at a time through the stack of four stories. The "Find" icon allowed the subject to type in a keyword for which the computer would search.

In the paper condition, the first page of the stack showed the titles of the four stories in the order that they appear in the stack.

Based on a pre-test questionnaire, subjects were categorized by level of search experience -- novice, moderate, and expert. The search experience questionnaire considered experience searching both paper- and computer-based information sources.

For example, the search experience questionnaire asked:

Estimate the total number of times you have used a computer to search for specific information

- a. less than 50
- b. 50 - 100
- c. 101 - 150
- d. 151 - 200
- e. more than 200

The search experience questionnaire also asked subjects to estimate the total number of times they have "used printed (on paper) sources to search for specific information."

This experiment used three different types of news story -- news, sports and entertainment. Is information found more quickly and accurately in certain story types?

The news story search task was: The Hungarian bus left Budapest 15 months ago. Where did it go first?

The subject was given a stack of four news stories: 1) "Storm ravages U.S.," 2) "Hungarian bus stopped in Los Angeles," 3) "British economy takes a cautious turn upward," and 4) "Denver airport gets a new 'big top.'"

The subject's first challenge was to select the correct story. Then, the story was searched for the correct answer.

The answer to the news story search was "Moscow." In any modality, this answer was found embedded in a sentence about two-thirds of the way into the story: "The bus began its world tour 15 months ago. It left Budapest for Moscow, crossed the Asian subcontinent, went to Singapore, and traversed Australia before it arrived in America." In the multimedia condition, the answer also could be found in the video. An animated map and an announcer's voice revealed the answer in the first two seconds of the video.

Apparatus

The multimedia and computer conditions were presented on a Macintosh iiCI with 16-bit color using System 7 and QuickTime extensions.

The QuickTime movies were digitized from VHS videotape using a videocassette recorder and a Macintosh Quadra. Two Cyquest drives were used to accommodate the reloadable hard disks required to store the video clips.

The paper condition was produced by printing the computer condition using an Apple color laser printer.

Hypercard was used to program the experimental orders and control the images and movies.

Each experimental session was recorded on videotape as a backup for coding, and a stopwatch was used to clock reading times and search times. The Search Experience Questionnaire was a pencil-and-paper instrument.

Procedure

After signing a Consent Form, each subject completed a Search Experience Questionnaire.

The subject was instructed that this experiment involved finding specific information from three different stacks of stories, each stack containing four stories. The subject was told he or she would be evaluated on how fast and how accurately the information was found.

As determined by experimental order, the experimenter directed the subject to the stack to search first, second and third.

The subject was reminded that some stories included a movie that could be activated with the mouse.³

A training session was conducted to familiarize the subject with the search functions and to practice different strategies of finding specific information.

To begin the experiment, the experimenter asked a question (the search task) and said "Go" to begin each search. The subject pointed at the answer and said the answer out loud to stop the search. A stopwatch was used to time the search.

Three search tasks were administered -- one per stack. Each stack contained four stories of one story type.

The subject could ask the experimenter to repeat the question at any time. And, if the subject gave an incorrect answer, the experimenter said, "Continue your search."

The experimenter recorded the search path on paper. The search path was evaluated later to determine the number of search errors.

³ The answers to two of the three questions were included in both the text and the video. The answer to the third question was found only in the text.

RESULTS

SPSS (version 4.0) was used for the data analysis.

Analysis of variance was used to analyze the results of this experiment. The analysis of variance tested for main effects. This allowed the researcher to make statements such as: The effect of modality on search time was [this].

"Contrasts" were run to test differences between the levels of the experimental factors. A Contrast is a focused F-test that allowed the researcher to specify a specific hypothesis to compare one set of means versus another set of means. Contrast is a one degree of freedom F-test performed from within the ANOVA. This allowed the researcher to make statements such as: The paper modality was significantly different than the computer modality for effects on reading time. Contrasts have been reported in tables as "[this level of a variable] vs [that level of a variable]."

Did the subjects choose to search the QuickTime movie?

One use of newspapers is "hunting" for specific information.⁴ Newspapers of the future that apply interactive multimedia systems must facilitate information location. To be effective (and marketable), the video and audio content of the multimedia message must be considered a valuable source of information.

The question (R1) was: Do subjects choose to search the video?

Analysis showed that 10 of the 75 subjects (13 percent) chose to search the QuickTime video.

The act of selecting and viewing the QuickTime movie resulted in increased search times for the multimedia condition.

⁴ For different types of search strategies, see Alexander, 1936; Bates, 1979, 1981; Belkin & Croft, 1987; Bellardo, 1985; Blair, 1980; Bunge, 1967; Burkhardt, 1971; Carlson, 1964; Cook, 1984; Crow & Starbird, 1992; Dolan, 1979; Dreher & Guthrie, 1990; Elchesen, 1978; Fenichel, 1980-81; Fidel, 1984; Fidel & Soergel, 1983; Fidler, 1991a; Guthrie, 1988; Guthrie, Britten, & Barker, 1991; Hawkins, 1991; Hewins, 1990; Hildreth, 1989; Jahoda & Olson, 1972; Joseph, Steinberg, & Jones, 1989; Katz, 1974; Kennington, 1977; Kerr, 1986; Kolers, Duchnick, & Ferguson, 1981; Marchionini, 1989; Martinson, 1970, 1972; Matazzoni, 1992; McGoldrick, Martin, & Bergering, 1989; Miller, 1988; Morrow, 1976; Nelson, 1991; Pullinger, 1984; Reinking & Bridwell-Bowles, 1991; Saracevic et al, 1988; Slatin, 1990; Stych, 1966; Thompson & Croft, 1989; Van Nes, 1986; Wang, Liebscher, & Marchionini, 1988).

Search time as a function of search experience

To test for a main effect for search experience, this experiment predicted:

H1 A significant main effect will exist for search experience on search time. Expert searchers should have the shortest search times, followed by moderates and novices in that order.

The evidence did not support H1. No main effect was found for search time as a function of search experience ($F(2) = .40, p > .05$).

Also, means for the three levels of search experience by search time were nearly equal. Expert searchers had the lower search time ($M = 34.46$), followed by novice searchers ($M = 35.57$) and moderate searchers ($M = 35.61$) in that order.

No contrasts were performed because no main effect was found.

Search errors as a function of search experience

H2 A significant main effect will exist for search experience on search errors. Expert searchers should have the fewest search errors, followed by moderates and novices in that order.

Evidence found by this study did not support H2. No main effect was found for search errors as a function of search experience ($F(2) = .64, p > .05$).

Search errors were nearly equivalent across levels of search experience. Novice searchers and expert searchers both had mean search errors scores of .75, while moderate searchers had a mean search error score of .77.

No main effect was found, so no contrasts were performed.

Search time as a function of modality

To test for a main effect for modality by search time, this study predicted:

H3 A significant main effect will exist for modality on search time. The paper modality should yield the shortest search times, followed by computer and multimedia in that order.

This study supports H3. A significant main effect was found for search time as a function of modality ($F(2) = 4.59, p < .05$). (See [Table 1](#).)

The paper modality had the lower search times ($M = 28.39$), followed by computer ($M = 37.64$) and multimedia ($M = 39.67$) in that order. (See [Figure 5](#).)

A significant difference was found for search time between the paper and multimedia levels of the modality factor ($F(1) = 8.49, p < .01$).

No other differences were found for search time between levels of the modality factor.

Table 1. Results of ANOVA and Contrasts for search time as a function of modality

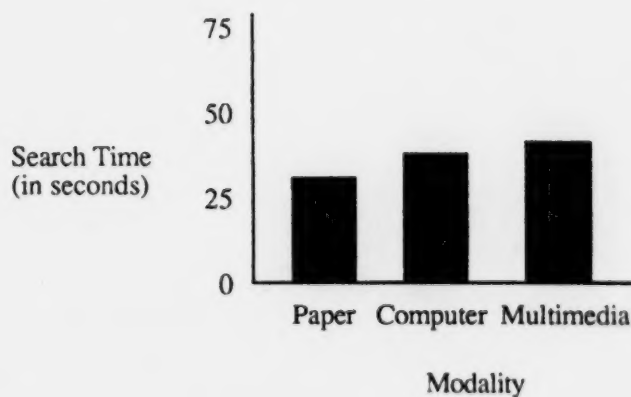
Variable	Mean	MS	df	F
MODALITY		2768.88	2	4.59*
Paper	28.39			
Computer	37.64			
Multimedia	39.67			
Paper vs Multimedia		5123.20	1	8.49**
Computer vs Multimedia		329.61	1	.55
Paper vs Computer		1.78	1	1.34

* $p < .05$

** $p < .01$

*** $p < .001$

Figure 5. Mean search time as a function of modality



Search errors as a function of modality

To test for main effects for modality by search errors, this experiment predicted:

H4 A significant main effect exists for modality by search errors. The paper modality should yield the lowest number of search errors. The number of search errors in the computer and multimedia modalities may be nearly equal.

This study does not support H4. Although the number of search errors was lower for paper ($M = .64$) and computer ($M = .83$) and multimedia ($M = .80$) were nearly equal, no main effect was found for search errors as a function of modality. No contrasts were conducted.

Search time as a function of modality by search experience

Although no interactions could be tested for significance, interactive elements could be shown in graphic form.

The following depiction of search time as function of modality by search experience may serve as a baseline for comparison by future studies.

Figure 6. Search time as a function of modality by search experience

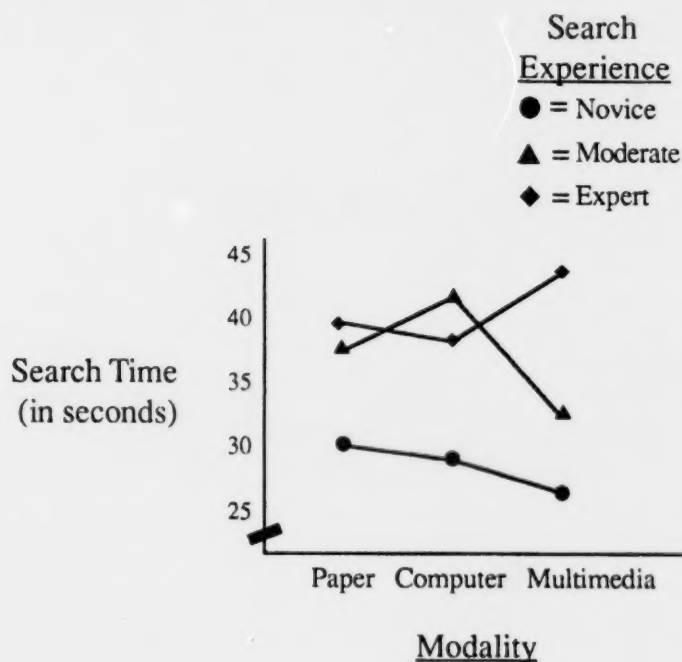


Figure 6 demonstrates that, for search time as a function of search experience by modality, novices consistently had the lowest search times.

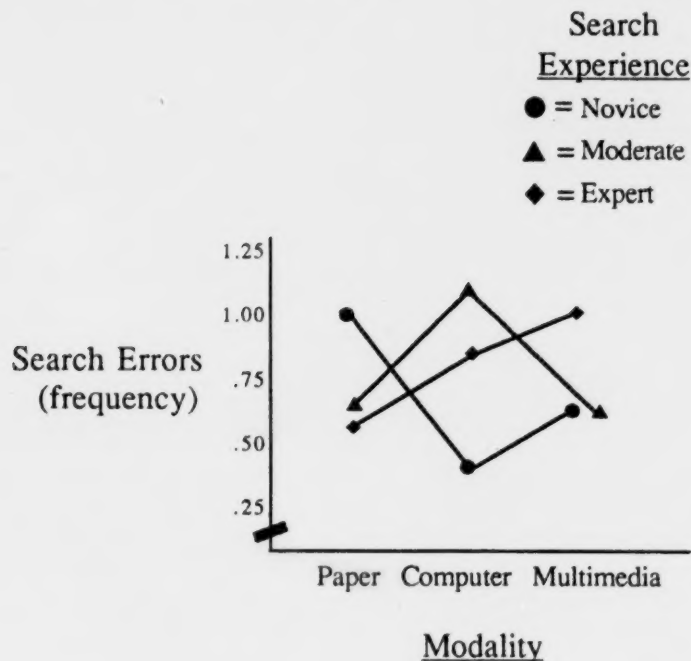
Expert searchers had the highest search times for the paper and multimedia conditions and the second highest search times for the computer condition.

Moderate searchers had the highest search times for the computer condition and the second highest search times for the paper and multimedia conditions.

Search errors as a function of modality by search experience

For search errors as a function of modality by search experience, the following figure was constructed.

Figure 7. Search errors as a function of modality by search experience



For search errors as a function of search experience by modality, **Figure 7** demonstrates that expert searchers showed an upward trend in frequency of search errors as they searched paper, computer and multimedia conditions. Searchers with moderate experience jumped up in error

frequency for the computer condition, then came back to "level" between the paper and multimedia conditions.

Novice searchers had the highest frequency of errors for searching paper. Yet, novice searchers had the lowest frequency of search errors for both the computer and multimedia conditions.

Search time as a function of story type

This study asked:

R2 Does a significant main effect exist for story type by search time? What story type results in the shortest search times? longest search times?

A significant main effect was found for search time as a function of story type ($F(2) = 9.73, p < .001$). (See Table 2.)

The sports stories had the shorter search times ($M = 25.97$), followed by news ($M = 34.67$) and entertainment ($M = 45.05$) in that order. (See Figure 8.)

Significant differences were found for search time between the news and entertainment levels of the story type factor ($F(1) = 4.74, p < .05$) and between the sports and entertainment stories ($F(1) = 19.46, p < .001$). However, no difference was found for search time between the news and sports stories.

Table 2. Results of ANOVA and Contrasts for search time as a function of story type

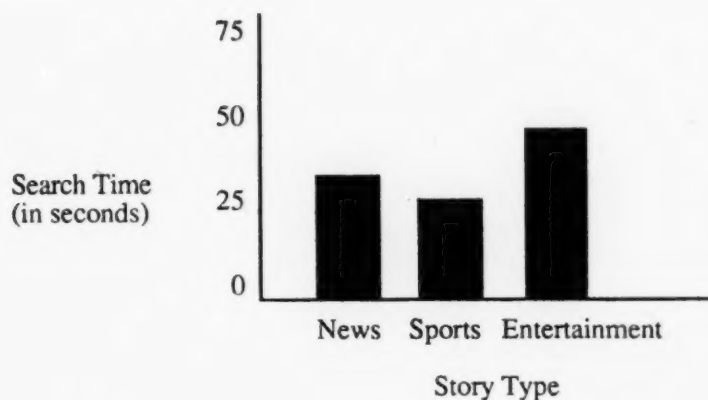
Variable	Mean	MS	df	F
STORY TYPE		5872.97	2	9.73***
News	34.67			
Sports	25.97			
Entertainment	45.05			
News vs Entertainment		2860.45	1	4.74*
Sports vs Entertainment		11,745.28	1	19.46***
News vs Sports		.56	1	.42

* $p < .05$

** $p < .01$

*** $p < .001$

Figure 8. Mean search time as a function of story type



Search errors as a function of story type

To examine effects of story type on search errors, this study asked:

R3 Does a significant main effect exist for story type on search errors? What story type yields the fewest search errors? the most?

A significant main effect was found for search errors as a function of story type

($F(2) = 5.98, p < .01$). (See [Table 3](#).)

The sports stories had the fewest search errors ($M = .47$), followed by news ($M = .61$) and entertainment ($M = 1.19$) in that order. (See [Figure 9](#).)

Significant differences were found for search errors between the news and entertainment stories ($F(1) = 6.85, p < .05$) and between the sports and entertainment stories ($F(1) = 10.68, p < .01$). But, no difference was found for search errors between the news and sports stories.

Table 3. Results of ANOVA and Contrasts for search errors as a function of story type

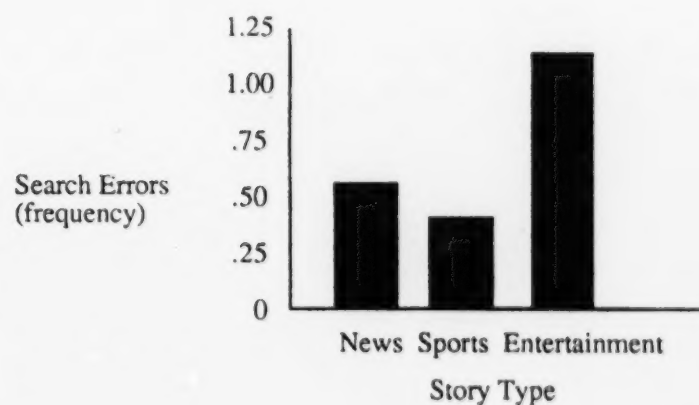
Variable	Mean	MS	df	F
STORY TYPE		7.96	2	5.98**
News	.61			
Sports	.47			
Entertainment	1.19			
News vs Entertainment		9.12	1	6.85*
Sports vs Entertainment		14.21	1	10.68**
News vs Sports		.56	1	.42

* $p < .05$

** $p < .01$

*** $p < .001$

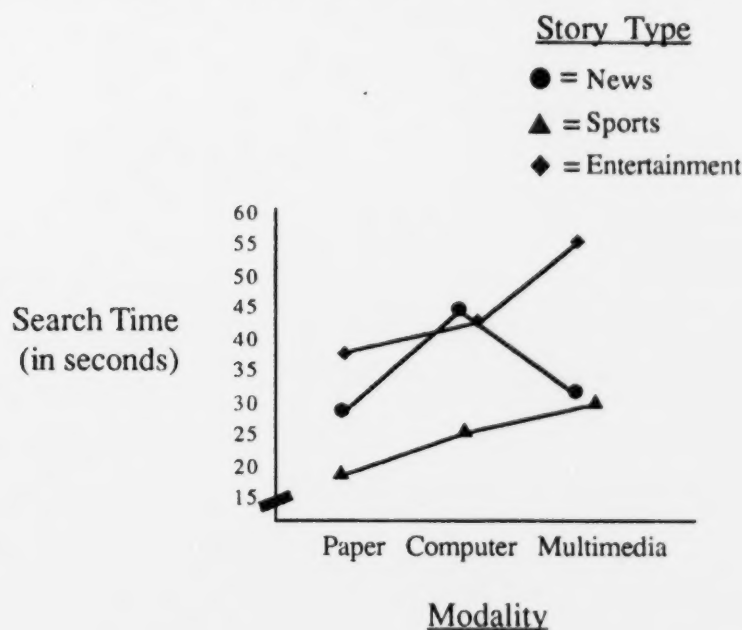
Figure 9. Mean search errors as a function of story type



Search time as a function of modality by story type

The following figure depicts the interactive elements of modality and story type as measured by search time.

Figure 10. Search time as a function of modality by story type



For search time as a function of modality by story type, [Figure 10](#) demonstrates that sports stories consistently had the lowest search times, although those times increased from the paper to computer to multimedia conditions. Search time for news stories was second highest for both the paper and multimedia conditions, but jumped to highest for the computer condition. Entertainment stories had the highest search time for both the paper and multimedia conditions. Entertainment stories had slightly lower search times than news stories in the computer modality.

Search errors as a function of modality by story type

Interactive elements of modality and story type as measured by search errors are depicted in the following figure.

Figure 11. Search errors as a function of modality by story type

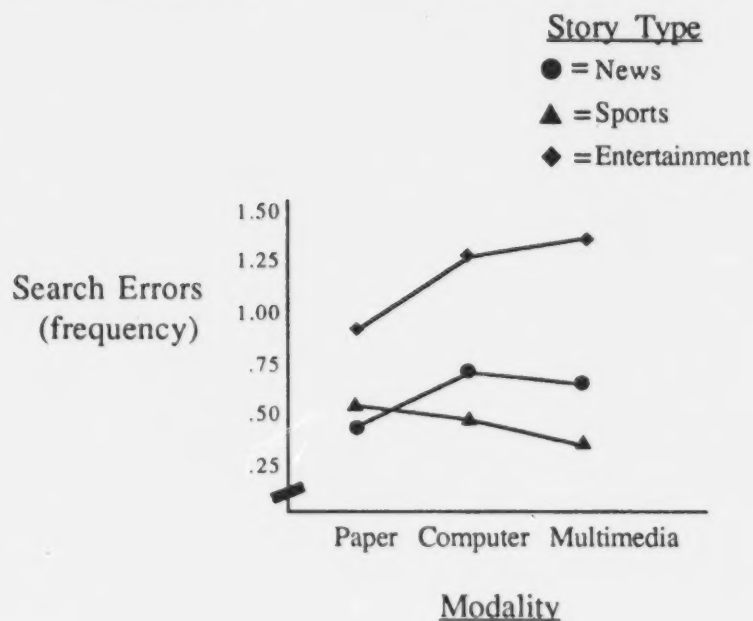


Figure 11 demonstrates that, for search errors as a function of modality by story type, the entertainment stories consistently had the highest search error rate. Sports stories were second highest for search errors in the paper condition, but they had the fewest search errors for both the computer and multimedia conditions.

Search time as a function of experimental order

This study asked:

R4 Does a significant main effect exist for order on search time? What order (combination of modalities with story types) yields the shortest search times? the longest?

Order #1 included the following combinations of story type and modality: news + computer, sports + paper, and entertainment + multimedia.

Order #2 included the following combinations of story type and modality: news + multimedia, sports + computer, and entertainment + paper.

Order #3 included the following combinations of story type and modality: news + paper, sports + multimedia, and entertainment + computer.

No main effect was found for search time as a function of order ($F(2) = .39, p > .05$).

Order #2 had the lower search times ($M = 31.69$), followed by Order #3 ($M = 34.55$) and Order #1 ($M = 39.65$) in that order.

Contrasts were not performed because no main effect was found.

Search errors as a function of experimental order

To examine the effects on order on search errors, this study asked:

R5 Does a significant main effect exist for order on search errors? What order is associated with the fewest search errors? the most?

No main effect was found for search errors as a function of order ($F(2) = .16, p > .05$), and, therefore, no contrasts were performed.

Order #2 had fewer search errors ($M = .69$), followed by Order #3 ($M = .71$) and Order #1 ($M = .87$) in that order.

DISCUSSION AND FUTURE RESEARCH

This experiment tested search time and search accuracy across three levels of search experience (novice, moderate, expert), three modalities (paper, computer, multimedia), and three story types (news, sports, entertainment). Only 13 percent of the subjects chose to view the multimedia video as a search strategy.

Although existing literature argues for a search experience factor, no effects were found for search experience for either search time or number of search errors.

Modality did affect search time. On-paper searches had the shortest elapsed times. Search times for computer and multimedia searches were nearly equivalent.

No effect was found for search errors as a function of modality.

Effects were found for search time as a function of story type. Searches of entertainment stories were significantly longer than either news or sports stories. Sports stories had the shortest search times.

Effects were found for search errors as a function of story type. Search errors for entertainment stories were significantly higher than either news stories or sports stories. Sports stories had the fewest search errors.

Why was there no significant difference between the computer and multimedia conditions for search time?

Only 13 percent of the subjects chose to see the video as part of their search strategy. Apparently, subjects did not regard the videos as effective search targets.

Future research may include subjects with more training and experience using multimedia.

No predictions were made for effects as a function of story type. Yet, story type was a significant factor for search time and search errors.

This research has shown that content factors such as story type are valuable elements of cross-modality research. Without accounting for such factors, findings of the effects of different modalities may be misleading.

This study may serve as a baseline for future studies that include more precise consideration of story type as a factor. For example, discourse analysis could be conducted to determine the propositional constructions of various story types. Do news and sports stories contain more "facts" than entertainment stories? Although readability measures may not detect them, are there inherent differences in the prose used for news, sports and entertainment stories?

Also, various story types may be stratified by measures of newsworthiness -- impact, timeliness, prominence, proximity, conflict, deviance, and salience (Mencher 1987, p. 62-67). How do these measures of "impact" affect performance of reading and search tasks?

The Latin Square design did not allow significance tests of interactions. Yet, figures shown in the Results section show "patterns" of interactions. Future studies that use fully factorial designs may use this study as a baseline for comparison of results.

The results of this study suggest that greater experience may not lead to faster searches. Why did the expert searchers fail to search faster than novices or moderates? Did the search functions provided by the computer raise novice searchers' awareness of the search process and its strategies?

As novice searchers, the search functions used for this research offered little or no interference with existing mental models of computer search. Perhaps the search performance of moderate and expert searchers suffered from such interference with existing knowledge of computerized search systems. In fact, a few expert searchers commented, during the practice session for the experiment, that this system was "different" than or "not as complicated" as the system with which they were most familiar.

Searching the videos in this experiment could have been an efficient strategy.

In the text, the answer to "Where did the Hungarian bus go first?" was found embedded in a list of locations about two-thirds of the way through the story. The text read, "The bus began its world tour 15 months ago. It left Budapest for Moscow, crossed the Asian subcontinent, went to Singapore, and traversed Australia before it arrived in America." In the video, the same answer -- Moscow -- was mentioned by the announcer and pointed out by an animated map within the first two seconds of the movie.

In the text, the answer to "What does the singer in 'Alladin' think her grandchildren will say?" was embedded in a long quote in the first third of the story. But, the sentence structure, a shift in "voice," confused subjects. The quote was:

"It's very flattering that one day my grandchildren will be watching 'Alladin' and I'll say, 'Your grandmother is the singing voice of that girl.' They'll probably look at me and say, 'Nah, you've gotta be kidding,'" Salonga said.

In the video, the singer is interviewed. The tone of her voice and her body language both convey the change of "person." This makes it more clear when the grandchildren "speak." Again, this occurs in only about five seconds.

The answer to the sports story was found only in the text.

Also, this researcher recommends further refinement of the Search Experience Questionnaire. Perhaps scoring the questionnaire could include high and low levels for both on-paper searches and on-computer searches.

The subjects who participated in the research conducted for this experiment had little or no experience with the multimedia modality. Subjects who have more extensive training or experience using multimedia information sources may be included in future studies. Also, young people who have used multimedia learning tools in classrooms may be included as experimental subjects.

Using this experiment as a baseline, studies may be designed that use more extensive information bases. This would allow researchers to expand the scope of search tasks (searching a greater number of content categories and a greater number of stories).

Other future research may provide subjects with various sources of the same information, whether paper, computer, or multimedia. A search task could be given, and the experimenter could watch how the subjects behave. Given control over selection of modality, what will subjects choose to use? What selections and shifts in search strategy do subjects make?

The future holds many possibilities. Newspapers of the future may apply multimedia technologies to news content. More cross-modality research may be conducted to examine the cognitive, behavioral and subjective effects of exposure to multimedia news sources.

References

- Alexander, C. (1936). Technique of library searching, *Special Libraries*, September, 27(7):230-238.
- Bain, C. (1980). Newspaper design and newspaper readership: A series of four experiments, D.H. Weaver & I. Woodley (Eds.), Research Report No. 10, Bureau of Media Research, Center for New Communications.
- Barnhurst, K.G. (1991). News as art, *Journalism Monographs*, December, No. 130. Columbia, South Carolina: Association for Education in Journalism and Mass Communication.
- Bates, M.J. (1979). Information search tactics, *Journal of the American Society for Information Science*, July, 30(4):205-214.
- Bates, M.J. (1981). Search techniques. In M.E. Williams, Ed., Annual Review of Information Science and Technology, 16:139-169.
- Belkin, N.J., & Croft, W.B. (1987). Retrieval techniques, In M.E. Williams, Ed., Annual Review of Information Science and Technology, 22:109-145.
- Bellardo, T. (1985). An investigation of online searcher traits and their relationship to search outcome, *Journal of the American Society for Information Science*, 36(4):241-250.
- Blair, D.C. (1980). Searching biases in large interactive document retrieval systems, *Journal of the American Society for Information Science*, July, 31(4):271-277.
- Bunge, C.A. (1967). Professional Education and Reference Efficiency, Research Series No. 11. Springfield, IL: Illinois State Library.
- Burkhardt, M. (1971). Anwendung der systematischen heuristik bei rechenen [Application of systematic searching techniques]. *Bibliothekar* (Germany), September, 25:628-632.
- Carlson, G. (1964). Search strategy by reference librarians: Part 3 of the Final Report on the Organization of Large Files. Sherman Oaks, CA: Hughes Dynamics, Inc., Advanced Information Systems Division.
- Chase, W.G., & Simon, H.A. (1973). Perception in chess, *Cognitive Psychology*, 4:55-81.
- Chi, M.T.H., Feltovich, P.J., & Glaser, P. (1981). Categorization and representation of physics problems by experts and novices, *Cognitive Science*, 5:121-152.
- Chi, M.T.H., Glaser, R., & Rees, E. (1982). Expertise in problem solving. In R.J. Sternberg (Ed.), Advances in the Psychology of Information Theory, 17, 2(3):113-124.
- Cook, P.R. (1984, July). Electronic encyclopedias, *Byte*, 9(7):151-170.
- Creed, A., Dennis, I., & Newstead, S. (1987). Proof-reading on VDUs, *Behaviour and Information Technology*, 6(1):1-13.
- Creed, A., Dennis, I., & Newstead, S. (1988). Effects of display format on proof-reading with VDUs, *Behaviour and Information Technology*, 7(4):467-478.

- Crow, R.W., Jr., & Starbird, R.F. (1992). Easier said than done: Practical considerations in user interface design, *Government Information Quarterly*, 9(2):169-185.
- Dillon, A., Richardson, J., & McKnight, C. (1990). The effects of display size and text splitting on reading lengthy text from screen, *Behaviour and Information Technology*, 9(3):215-227.
- Dolan, D.R. (1979, December). Before you touch the terminal: Flowchart of the search formulation process, *Database*, 2(4):86-88.
- Don, A. (1992). CineMacs: QuickTime makes movies on the small screen, *Publish*, May, 7(5):50-57.
- Dreher, M.J., & Guthrie, J.T. (1990). Cognitive processes in textbook chapter search tasks, *Reading Research Quarterly*, 25(4):323-339.
- Elchesen, D.R. (1978). Cost-effectiveness comparison of manual and on-line retrospective bibliographic searching, *Journal of the American Society for Information Science*, March, 29(2):56-66.
- Fenichel, C.H. (1980-81). The process of searching online bibliographic databases: A review of research, *Library Research*, 2(2):107-127.
- Fidel, R. (1984). Online searching styles: A case-study-based model of searching behavior, *Journal of the American Society for Information Science*, 35(4):211-221.
- Fidel, R., & Soergel, D. (1983). Factors affecting online bibliographic retrieval: A conceptual framework for research, *Journal of the American Society for Information Science*, 34(3):163-180.
- Fidler, R. (1991a). Harnessing the new technology. Speech delivered at the American Press Institute's "Journalism Educators Seminar" in Reston, Virginia, October 8, 1991.
- Fidler, R. (1991b). Mediamorphosis, or the transformation of newspapers into a new medium, *Media Studies Journal*, Fall (pp. 114-12). The Freedom Forum Media Studies Center, New York: Columbia University.
- Gittins, D. (1986). Icon-based human-computer interaction, *International Journal of Man-Machine Studies*, 24(6):519-543.
- Guastello, S.J., & Traut, M. (1989). Verbal versus pictorial representations of objects in a human-computer interface, *International Journal of Man-Machine Studies*, 31(1):99-120.
- Guthrie, J.T. (1988). Locating information in documents: Examination of a cognitive model, *Reading Research Quarterly*, Spring, 23(2):178-199.
- Guthrie, J.T., Britten, T., & Barker, K.G. (1991). Roles of document structure, cognitive strategy, and awareness in searching for information, *Reading Research Quarterly*, 26(3):300-324.
- Guthrie, J.T., & Kirsch, I.S. (1987). Distinctions between reading comprehension and locating information in text, *Journal of Educational Psychology*, 79(3):220-227.

- Guthrie, J.T., & Mosenthal, P. (1987). Literacy as multidimensional: Locating information and reading comprehension, *Educational Psychologist*, 22(3&4):279-297.
- Haas, C., & Hayes, J. (1985a). Effects of text display variables on reading tasks: Computer screen vs. hard copy (CDC Technical Report No. 3). Pittsburgh, PA: Carnegie-Mellon University, Communications Design Center.
- Haas, C., & Hayes, J. (1985b). Reading on the computer: A comparison of standard and advanced computer display and hard copy (CDC Technical Report No. 7). Pittsburgh, PA: Carnegie-Mellon University, Communications Design Center.
- Hawkins, D.T. (1991, March). Videotex markets, applications, and systems, ONLINE, 15(2):97-100.
- Hewins, E.T. (1990). Information need and use studies. In M.E. Williams (Ed.), Annual Review of Information Science and Technology (ARIST), Vol. 25, 145-172.
- Hildreth, C.R. (1989). Intelligent interfaces and retrieval methods for subject searching in bibliographic retrieval systems. Washington, DC: Library of Congress.
- Jahoda, G., & Olson, P.E. (1972). Models of reference: Analyzing the reference process, *RQ*, Winter, 12(2):148-156.
- Joseph, B., Steinberg, E.R., & Jones, A.R. (1989). User perceptions and expectations of an information retrieval system, *Behaviour and Information Technology*, 8(2):77-88.
- Kahney, H. (1983). What do novice programmers know about recursion? In A. Janda (Ed.), Human Factors in Computing Systems: CHI'83 Conference Proceedings (pp. 235-239). New York: ACM.
- Katz, W.A. (1974). Introduction to Reference Work, 3rd edition, 2 volumes, New York: McGraw-Hill.
- Kennington, K. (1977). Scanning the operational environment: The librarian's role, *Journal of Librarianship* (U.K.), October, 9(4):261-269.
- Kerr, S.T. (1986). Instructional text: The transition from page to screen, *Visible Language*, 20(4):368-392.
- Kirsch, I.S., & Guthrie, J.T. (1984). Adult reading practices for work and leisure, *Adult Education Quarterly*, Summer, 34(4):213-232.
- Kirsch, I.S., & Mosenthal, P.B. (1990). Exploring document literacy: Variables underlying the performance of young adults, *Reading Research Quarterly*, Winter, 25(1):5-30.
- Kolers, P.A., Duchnicky, R.L., & Ferguson, D.C. (1981). Eye movement measurement of readability of CRT displays, *Human Factors*, 23(5):517-527.
- Larkin, J.H. (1980). Understanding Problem Representations and Skill in Physics (Tech. Rep. Applied Cognitive Psychology No. 2). Pittsburgh, PA: Carnegie-Mellon University, Department of Psychology.
- Larkin, J.H. (1983). Mechanisms of Effective Problem Representation in Physics (CIP No. 434). Pittsburgh, PA: Carnegie-Mellon University, Department of Psychology.

- Leung, L.W.C. (1989). Understanding human-computer communication: An examination of two interface models Doctoral experiment, The University of Texas at Austin, 1989).
- McGoldrick, J.A., Martin, J., & Bergering, A.J. (1989). Locating discrete information in text: Effects of computer presentation and menu formatting. Unpublished manuscript, University of Western Ontario, London.
- Marchionini, G. (1989). Making the transition from print to electronic encyclopaedias: Adaptation of mental models, *International Journal of Man-Machine Studies*, 30(6):591-618.
- Marmion, D. (1990). Hypertext: Link to the future, *Computers in Libraries*, 10(6):7-9.
- Martinson, T.L. (1970). A simple stratified flow chart for compiling subject bibliographies in geography, *Special Libraries Association Geography and Map Division Bulletin*, December, 82:32-41.
- Martinson, T.L. (1972). Library of Congress author catalogs: A "micro-series" in the stratified flow chart, *Special Libraries Association Geography and Map Division Bulletin*, March, (87):12-16.
- Matazzoni, J. (1992, October). Alice on disk! A California publisher experiments with electronic books, *Publish*, 7(10):16-21.
- Mencher, M. (1987). News reporting and writing. Fourth Edition. Dubuque, IA: Wm. C. Brown Publishers. pp. 62-67.
- Miller, T. (1988, September 10). Data bases: Finding your world in the electronic newspaper, *Editor & Publisher*, 121(37):34-44.
- Morrow, D.I. (1976). A generalized flowchart for the use of ORBIT and other on-line interactive bibliographic search systems, *Journal of the American Society for Information Science*, January-February, 27(1):57-62.
- Muter, P., & Mayson, C. (1986). The role of graphics in item selection from menus, *Behaviour and Information Technology*, 5(1):89-95.
- Nelson, M.J. (1991). The design of a hypertext interface for information retrieval, *The Canadian Journal of Information Science*, 16(2):1-12.
- Nielsen, J. (1990). The art of navigating through hypertext, *Communications of the ACM*, March, 33(3):296-310.
- Norman, D.A. (1981). Twelve issues for cognitive science. In D.A. Norman (Ed.), Perspectives on Cognitive Sciences (pp. 265-295). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Norman, K.L., & Schwartz, J.P. (1987). Memory for hierarchical menus: Effects of study mode, *Bulletin of the Psychonomic Society*, 25(3):163-166.
- Oborne, D.J., & Holton, D. (1988). Reading from screen versus paper: There is no difference, *International Journal of Man-Machine Studies*, 28(1):1-9.
- Pasternack, S., & Utt, S.H. (1986). Subject perception of newspaper characteristics based on front page design, *Newspaper Research Journal*, Fall, 8(1):29-35.

- Pipps, V.S. (1985). Measuring the effects of newspaper graphic elements on reader satisfaction with a redesigned newspaper using two methodologies (Doctoral experiment, Syracuse University, 1985).
- Pullinger, D.J. (1984). Design and presentation of *Computer Human Factors* journal on the BLEND system, *Visible Language*, Spring, 18(2):171-185.
- Reinking, D., & Bridwell-Bowles, L. (1991). Computers in reading and writing. In R. Barr, M.L. Kamil, P.B. Mosenthal, & P.D. Pearson, (Eds.), Handbook of Reading Research, Vol. 2 (pp. 310-340). New York: Longman.
- Rumelhart, D.E., & Norman, D.A. (1981). Analogical processes in learning. In J.R. Anderson (Ed.), Cognitive Skills and Their Acquisition (pp. 335-359). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Saracevic, T., Kantor, P., Chamis, A.Y., & Trivison, D. (1988). A study of information seeking and retrieving, *Journal of the American Society of Information Science*, 39(3):161-216.
- Simon, D.P., & Simon, H.A. (1978). Individual differences in solving physics problems. In R. Siegler (Ed.), Children's Thinking: What Develops? (pp. 325-348). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Slatin, J.M. (1990). Reading hypertext: Order and coherence in a new medium, *College English*, December, 52(8):870-883.
- Stych, F.S. (1966). The flow chart method, *RQ*, Summer, 5(4):14-17.
- Thompson, R.H., & Croft, W.B. (1989). Support for browsing in an intelligent text retrieval system, *International Journal of Man-Machine Studies*, 30(6):639-668.
- Tinker, M.A. (1946). The study of eye movements in reading, *Psychological Bulletin*, 43(2):93-120.
- Tinker, M.A. (1966). Bases for effective reading. Minneapolis, MN: University of Minnesota Press.
- Van Nes, F.L. (1986). Space, colour and typography on visual display terminals, *Behaviour and Information Technology*, 5(2):99-118.
- Wang, X., Liebscher, P., & Marchionini, G. (1988). Improving information seeking performance in hypertext: Roles of display format and search strategy, College of Library and Information Services Report CAR-TR-353/CS-TR-2006, January. University of Maryland: College Park, MD.
- Wilkinson, R.T., & Robinshaw, H.M. (1987). Proof-reading: VDU and paper text compared for speed, accuracy and fatigue, *Behaviour and Information Technology*, 6(2):125-133.
- Wright, P., & Lickorish, A. (1983). Proof reading texts on screen and on paper, *Behaviour and Information Technology*, 2:227-235.